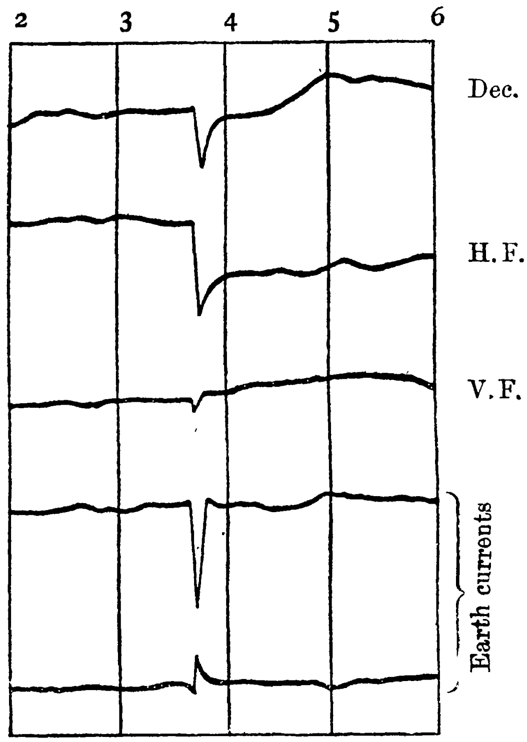
will be at once accompanied by an equally abrupt earth-current. At times isolated instances of this feature arise. An interesting illustration of a case of this kind, showing the close relation that exists on such occasions between magnetic and earth-current movements, is that occurring at Greenwich on 1893 February 14 at $3^h\ 45^m$ in the morning, when the isolated magnetic movements, though not large (in declination only four minutes of arc), were

1893 *February* 14, *Morning.*



Isolated magnetic and earth current movement recorded at Greenwich (copy of photograph).

accompanied by corresponding marked earth-current, the different elements all being in a quiescent state both before and after the little outbreak. It may be further noted that the diagram indicates increase of declination and of horizontal and vertical force, the movements being in this respect in harmony with the usual Greenwich direction of first movement in storms, as shown in Table II.

Provisional Elements of Jupiter's Satellite VI.

By A. C. D. Crommelin.

The information contained in *Publications of the Astronomical Society of the Pacific*, vol. xvii. No. 100, renders it tolerably certain that this object is really a satellite of *Jupiter*. Professor Aitken's visual observation with the 36-inch refractor proves that it is a real body in our system, not a mere series of

photographic defects; while the fact of its positions being in cacord with those of a satellite for a period of over eight weeks renders the hypothesis of its being a minor planet extremely improbable, though perhaps not absolutely impossible. Under these circumstances, and in view of the fact that the Lick observers are waiting for further observations before publishing definitive elements, it seems worth while to give a rough approximation to the orbit, which I have deduced from the material already available: this is quite insufficient to deduce the eccentricity, so that the orbit is necessarily assumed to be circular.

The following table contains all the available material:

1904 December 3, 8, 9, 10.—Satellite west of *Jupiter* and receding from it.

1904 December 25.—West elongation, distance about 50′.

1905 January 4·7 G.M.T.—Distance 45′, position-angle 269°. Approaching *Jupiter* 45″ daily.

1905 January 17·7 G.M.T.—Distance 36′, position-angle 266°.

1905 January 28.—Approaching *Jupiter* about 1′ daily.

Taking first the elongation distance as exactly 50′, I examined how nearly this would represent the positions on January 4 and 17. It is necessary to do this independently on the two hypotheses of direct and retrograde orbital motion, since we cannot as yet distinguish between these. I may remark that the Lick astronomers have now definitely stated that the phrase "apparent motion retrograde" in the original telegram had reference only to the diminishing position-angle; it was fairly obvious from the nature of the case that this must be so, though several astronomers interpreted it as referring to the orbital motion. It may perhaps be suggested that the words "position-angle diminishing" should be used in similar cases in the future to avoid all ambiguity. An elongation distance of 50′ on 1904 December 25 implies that the distance of the satellite from *Jupiter* is 0·0668 in astronomical units, or about 6,200,000 miles, the corresponding sidereal period being 204 days.

From these data the computed angular distances from *Jupiter* are as follows:

G.M.T.	Computed Distance.		Observed Distance.
	Direct Orbit.	Retrograde Orbit.	
	′	′	′
1905 January 4·7	45·8	46·0	45
17·7	35·4	34·3	36

It will be seen that the results are slightly more accordant on the "direct" hypothesis; but no stress can be laid on this, since the discordances may be due to eccentricity in the orbit or an error in the assumed epoch of elongation. It appears probable that the assumed distance of the satellite at elongation is correct within one or two per cent., and the observations do not permit of a more precise determination.

The calculated rate of approach to *Jupiter* is 42″ daily on January 4, 72″ on January 28, these values being tolerably accordant with the observed values given above.

To find the approximate position-angle of the apse it is sufficient to note that the linear velocity parallel to the minor axis of the apparent ellipse, being a maximum at the apse, is nearly uniform for some days after this. This method gave 270°·7 as the position-angle, which a second approximation altered to 270°·9. The deduced minor semi-axis of the apparent ellipse on December 25 is 4′·96.

If ϕ be the angle between the line of sight on December 25 and the orbit plane, then $\sin\phi = \frac{4\cdot96}{50}$, and $\phi = 5°\cdot7$.

Then to find the pole of the orbit plane we must proceed along the minor axis of the apparent ellipse (*i.e.* in position-angle 0°·9) to a distance of 84°·3 on the hypothesis of direct orbital motion, or 95°·7 on the retrograde hypothesis. The two points thus indicated were marked on a large scale map, and their distances from the poles of *Jupiter's* equator and orbit were measured with the following results:

	Direct Hypothesis.	Retrograde Hypothesis.
Inclination of satellite's orbit to plane of *Jupiter's* equator	26°·0	24°·7
" " " " " orbit	23·8	23·9

It may be noted that the position of the orbit plane would not be greatly altered by a moderate eccentricity of the orbit. We may, in fact, regard it as certain that, if the object be a satellite of *Jupiter* at all, its orbit plane is inclined at least 20° to both the equator and the orbit of its primary. This large inclination is very surprising and perplexing. We have a partial analogy in the case of *Japetus* and *Phœbe*; but these deviate from the primary's equatorial plane towards its orbital plane, whereas the present body makes a large angle with both. The seventh satellite, judging from the meagre reports received, is inclined at a still higher angle and in a totally different direction. These new satellites are indeed impairing the symmetry of the solar system by the peculiarities of their orbits.

It is noteworthy that according to the direct hypothesis the pole of the orbit plane is only 1°·5 from our own north pole, so that in this case the major axis of the apparent ellipse will always point very nearly east and west. The satellite will again be in west elongation next July, and a determination of its position-angle then will probably be sufficient to decide the direction of orbital motion.

Unfortunately the numeration of *Jupiter's* satellites is now in precisely the same confusion as that of *Saturn's* system was before the numbers were abandoned and names substituted. A similar course would seem to be advisable here; the designation V. for the inner satellite was tolerated for a time, as it was

considered to be in a class by itself; but it has now got companions, so that this subterfuge disappears. The substitution of names for numerals is certainly more poetic, and abbreviations may be devised which would take no more space in printing than the present notation (e.g. *Io.*, *Eu.*, *Gan.*, *Cal.* for the four old satellites).

It may help to realise the relative distances of satellites from their primaries to point out that the distances of satellites V. and VI. from *Jupiter* are comparable with those of *Mercury* and *Uranus* from the Sun, while those of *Mimas* and *Phœbe* are comparable with those of *Mercury* and *Neptune*.

Benvenue, 55 *Ulandi Road, Blackheath, S.E.:*
1905 *March* 8.

The Later Leonids of 1904 *November*.
By Rev. S. J. Johnson, M.A.

As most of the observations obtained of this shower relate to what was seen in the earlier hours of the morning of November 15 last, they may perhaps be supplemented by some notes on the meteors nearer sunrise, or between 3.30 and 5.30 A.M. A perfectly clear sky and the absence of even the crescent Moon of 1903 favoured the display. During the two hours aforesaid I noticed twenty-five meteors (not quite all Leonids) between 3.30 and 4.30, and thirteen between 4.30 and 5.30; but from the circumscribed portion of the heavens presented to the observer through obstructions and the delay occasioned by recording the tracks it would be probably correct to multiply this number by 4. This would make just 100 meteors in the two hours. Comparing with 1903, when I noticed fifty-three in $1\frac{3}{4}$ hour, equivalent to about sixty in two hours, and multiplying again by 4, we obtain 240 for the same hours in the morning in 1903. This makes the stream of 1903 two and a half times as plentiful as that of 1904. A noteworthy point was the intense green colour of the larger ones, probably magnesium. Eleven were = ordinary 1st-magnitude stars, one = *Vega*, two = ♃, and one = ♀. The three brightest meteors seen were $14^{d}\ 16^{h}\ 10^{m}$ = ♃, across *Com. Beren.* $175°+28°$ to $198°+28°$, $14^{d}\ 16^{h}\ 14^{m}$ = ♀, very green. From about $195°+22°$ to about $202°+18°$, $14^{d}\ 17^{h}\ 16\frac{1}{4}^{m}$ = ♃, across χ *Leonis*, almost to *Mars*, $155°+19°$ to $167°+5°$.

Melplash Vicarage, Bridport:
March 4.
